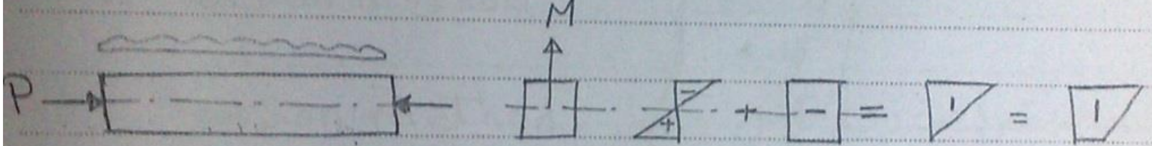
Pre Stressed Concrete خرسانات سابقة الإجهاد

introduction.

The idea of Prestressing was introduced to over Come The main dis advatage of Concrete, which is low tensile stress, through introducing Compressive longtudinal force (Pre stressing force).
The Prestressing force eleminate the tensile stress at tension Zone which is the main objective prestressing force



نضع normal force لكي تولد ضغط ع الألياف يعادل Tensile Stress الموجوده
على القطاع لكي يكون لنا no tensile stress

* advantages of Prestressing

1- Prevent the tensile stress and so there is no cracks
at tension Zone — هو يفيد في تقليل سمك القطاع

2 reduce the total depth of Section

3- كبير in harced the moment of internal of the Cross section and there fore decreasing the deflection
تقليل الهبوط

Page:---------------- Date:----------------

dis advatages

high Cost due to using high stress material

loss of Presstressing force

Comple cated detailes and technologe are required

في التسليح

Classifications of prestress

There are two Method of prestrssed

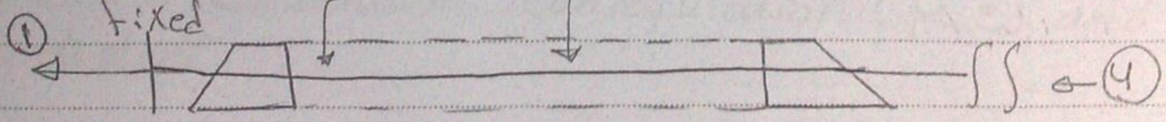
pre tension Method

Post tension method

pre tension method خرسانات سابقة الصب (شد الحامل)

is Method is used for pre Casting , The steel (tendoms) are tension before the Concrete is laced and after The Concrete is harding The steel s cut and the prestressed force will be applied at sec كبر الحديد

الـ Tendom عبارة عن مجموعة حديد ② Casting Concrete صب الخرسانة



tendom شد الـ

Casting of Concrete

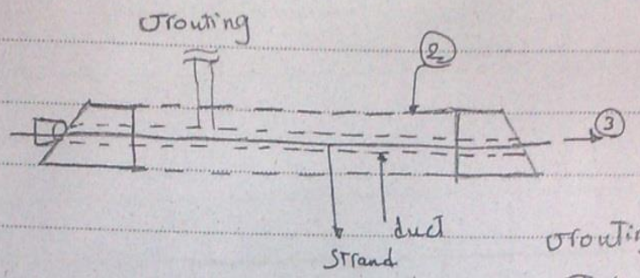
after harding Of Concrete بعد تصلب الخرسانة نبدأ جزء من الحديد

tendom انبت جزء منه في الاتجاه الآخر

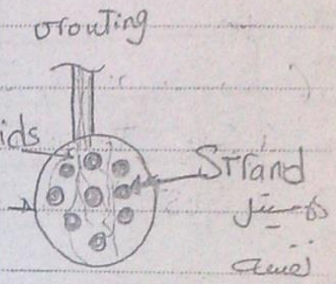
oint of cutting اقطع الآخر من الجانب cutting

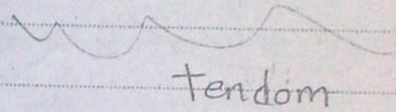
② Post tension Method

iT is used for situTion   ﻯ الموقع
The sTeel tendom is sTress ed after Concrete is harding



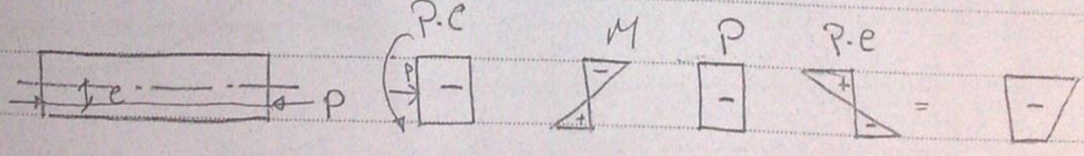
1) put tendom without tension
2- Casting of Concrete
3- sTressed of sTeel
4- Cutting

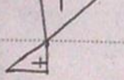


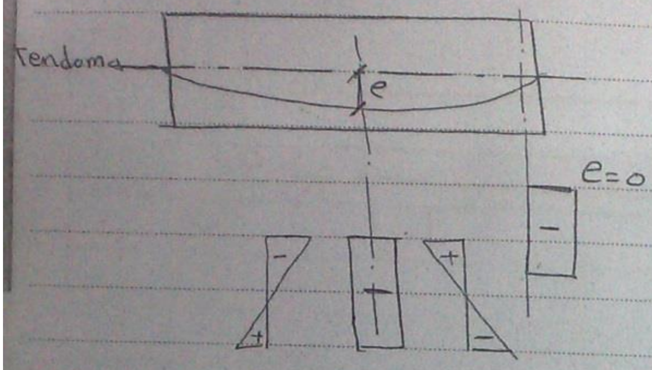


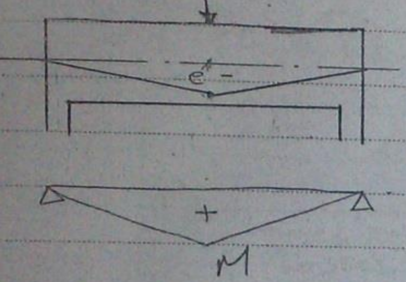
* Concept of prestress

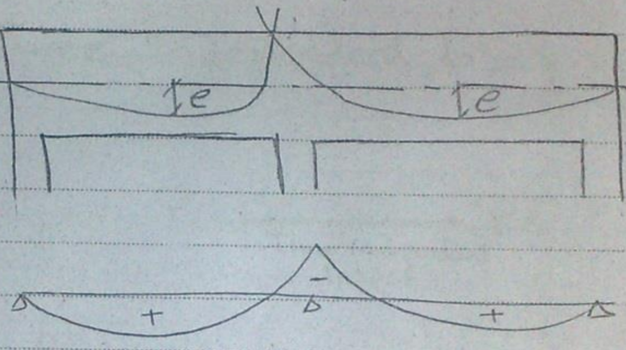
flecturestress inprestress member are the result of prestressed force, the internal MoMent due to ecentric, tendom Confeguration (P·e) and theapplied MoMent

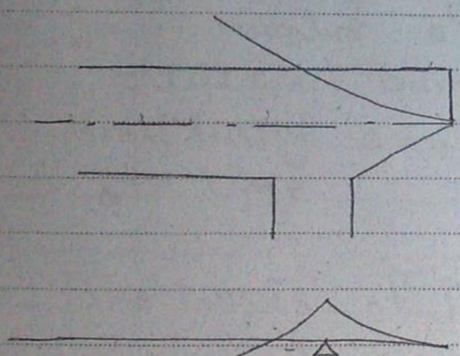


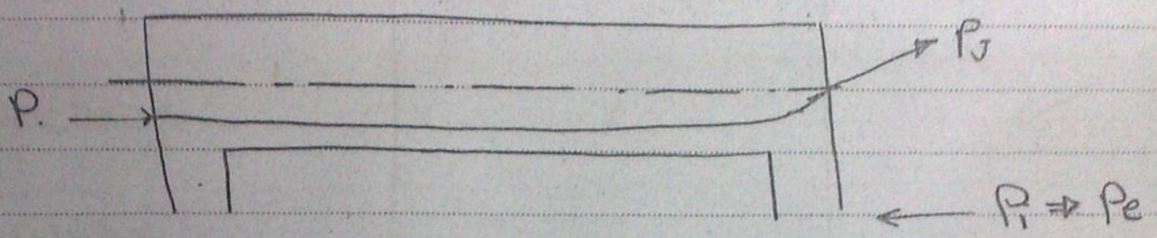
⇒ sTress لو عمل  بيك
- لما نزود tandum , بالتالى زياده التكلفه
او نعمل eccentricity لزياده الكفاءة
يتم وضع tandum ع شكل العزم


Tendoma
e
e=0


e
M


e
e





$P_i < P_j$ ⇒ initial immediatal

$P_e < P_i$ ⇒ time independent loses

$P_J \xrightarrow[\text{Losses}]{\text{immediately}}$ $P_i \xrightarrow[\text{losses}]{\text{time independant}} P_e$

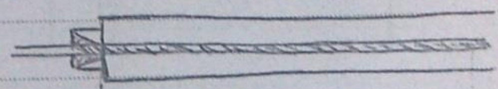
The applied prestressing force after Jacking under go, number of Reduction of force are occure. Sum of this Reduction occure imediatly and other occure over aperiod of time

The losses of forces intendom is Ranging from (10 → 25) of the jacking force

* losses — losses in prestressed Concrete

* Types of losses	Pretension	Posttension
1) Slip of anchorage ازلاق الصلب عند صفائح التثبيت	X	✓

يحدث في Post tension لأن الضغط الخارجي في هذه الحالة عند ارتداد الـ tendon
و ضغطه على القطاع Conical يمكن ان ينزلق و يحدث فقط في force



② elastic shortening	Pretension	Post
ΔE_{ES} نقص في طول الكمرة نتيجة قوة الانضغاط	✓	✓

← يحدث في هذه الحالة فقدان جزء من القوة نتيجة انضغاط الخرسانة
اثناء ارتداد الـ tendom ويحدث في Pre و post

③ friction		
ΔE_{Fr}	X	✓

← الثلاث حالات تعتبر Immediately losses

time indepent losses

	Pretension	Posttension
4- Shrinkage ΔF_{psh}	✓	✓
5- creep ΔF_{pc}	✓	✓
6- Reducation of steel ΔF_{pR}	✓	✓

4- فقدان الخرسانة نتيجة للانكماش

5- فقدان ال force نتيجة ارتخاء ال tendom داخل الخرسانة

1 anchorage slip losses (ΔF_{AS})

assume slip anchorage $(\Delta S) = 0.2$ cm (2-6) mm

Modulus of elasticity $E_{ps} = 2 * 10^6$ kg/cm²

$= 2 * 10^5$ N/mm²

$$\Delta F_{AS} = \frac{\Delta S}{L} * E_{ps}$$

L → length of tendom

ΔF_{AS} = losses of stress

[2] elastic shortening (Δf_{ES})

* for pre-tension when prestressing force is transfer to The concrete, The concrete shorten is occured and part of th prestressing is lost

$$\Delta f_{ES} = \frac{f_{pci}}{E_{ci}} * E_{ps}$$

where

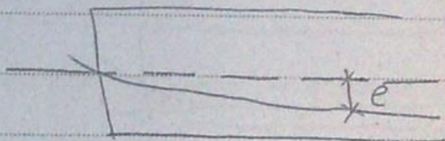
$$f_{pci} = \frac{-P_i}{A} - \frac{P_i * e * e}{I} + \frac{M_{o.w} * e}{I}$$

Δf_{ES} = losses of stress

$E_{ci} = 14000 \sqrt{f_{cui}}$

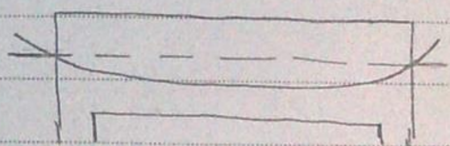
$f_{cui} = 0.45 \ f_{cu}$

$E_{cui} = 4400 \sqrt{f_{cui}}$ N/mm²



* for Post-tension

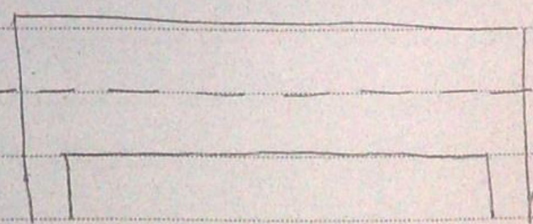
Δf_{ES} = Zero → for one tendom



→ for more one tendom

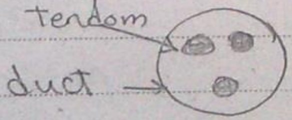
$$\Delta f_{ES} = \frac{1}{2} \frac{f_{pci}}{E_{ci}} * E_{ps}$$

→ لا تركز مع one tendom في حالة العزم الناتج من eccentricity



3 friction losses (Δf_{FR})

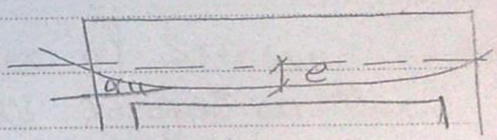
this type of losses exist only in post tention due to the friction between the tendom and the rrounding duct



$$\Delta f_{FR} = f_p(KL + \mu\alpha)$$

where

μ = is the friction Coefficient.
$\alpha = \frac{2e}{L}$
$K = 0.003 / m$
L = length of beam
$f_p = f_{pJ} - \Delta f_{AS}$
f_{pJ} =



wher
P_J = Jacking force
f_p = Area prestress steel

Page:

Date:

* long term losses (time independent losses)

$\boxed{4}$ shrinkage losses (Δf_{psh})

$\Delta f_{psh} = \varepsilon_{sh} * E_{ps}$

$\varepsilon_{sh} = 0.3 * 10^{-3}$ Pre - tension

$= 0.2 * 10^{-3}$ Post - tension

$\boxed{5}$ Creep losses (Δf_{pc})

$\Delta f_{pc} = \varepsilon_{cr} * E_{ps}$

$\varepsilon_{cr} = 0.48 * 10^{-3}$ pre -

$\varepsilon_{cr} = 0.36 * 10^{-3}$ Post -

$\boxed{6}$ Relasation steel losses (Δf_{pR})

is defined as the losses of stresses under constant strain and occure due to longation the tendom with time

$$\Delta f_{pR} = f_{pi} * \frac{\log 1000}{10} * \left[\frac{f_{pi}}{f_{py}} - 0.55\right]$$

where

$$f_{pi} = \frac{P_i}{A_{ps}}$$

$f_{py} = 0.85\ f_{pu}$

(f_{py}) The yielding stresses of prestressing steel

$f_{py} = (0.85 - 0.9)\ f_{pu}$

- يتم استخدام حديد عالي المقاومة لتوفير قطع الخرسانة.

+ لتحديد اللازم لتولد القوة tension اللازمة

Page:.................. Date:..................

$fpu = 1900$

$$\left.\begin{aligned} Epsw &= 0.7\ fpu \\ &= 0.8\ fpu \end{aligned}\right\}$$ الاكبر

ـه لا تزيد عن القيمه fpu حتى لا يحدث yeild forced

ex :

→ For the given Section, iT is required to fined The % of losses in The Following Cases

① Pre - Tension

② Post . tension

Jiven :

$A_{ps} = 300\ mm^2$

$P_i = 350\ KN$

$f_{cu} = 35\ N/mm^2$

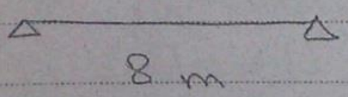
anchorage STrip = 2 mm

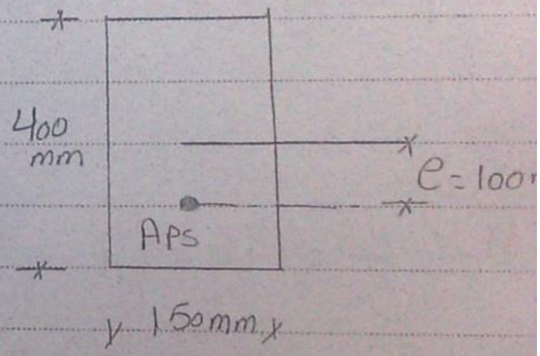
$L = 8000\ mm$

Steel grade 270 $f_{pu} = 1900\ N/mm^2$

$P_i = 350\ KN$

$E_{ps} = 2.1 * 10^5\ N/mm^2$





Sol :

* Properties of section

- $A_s = 150 * 400 = 60000$

- $I = \dfrac{150 * 400^3}{12} = 80000 * 10^4$

- $O.W.T = 0.15 * 0.4 * \underset{\downarrow}{25}_{KN/m^3} = 1.5\ KN/m$

- $M_{O.L} = O.W.T * \dfrac{L^2}{8} = 1.5 * \dfrac{8^2}{8} = 12\ KN * m$

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$$f_{pci} = \frac{-P_i}{A} - \frac{P_i * e * e}{I} + \frac{M_{o.w.} * e}{I}$$

$$\frac{350}{60000} - \frac{350*10^3*100*100}{80000*10^4} + \frac{12*10^6*100}{80000*10^4} = -6.87 \ N/mm^2$$

$$f_{pi} = \frac{P_i}{A_{ps}} = \frac{350*10^3}{300} = 1166.7 \ N/mm$$

$$E_c = 4400\sqrt{f_{cu}} = 4400\sqrt{35} = 23030.8 \ N/mm^2$$

$$f_{cui} = .75 f_{cu} = .75 * 35 = 26.26 \ N/mm^2$$

$$E_{ci} = 4400\sqrt{f_{cui}} = 4400\sqrt{26.26} = 22543.3 \ N/mm^2$$

assume immediatly losses = 10%

$\therefore \ P_i = (1-0.1) P_J$

$350 = 0.9 * P_J \qquad \therefore \ P_J = 388.89 \ KN$

$$f_{pj} = \frac{388.89}{300} = \frac{P_J}{A_{ps}} = 1296.3 \ N/mm^2$$

Date:

for immediatly losses

Pre-tension

① anchorage slip

Zero %

② elastic Shorting

$\Delta f_{ES} = \frac{f_{pci}}{E_{ci}} * E_{ps}$

$= \frac{6.87}{2254} * 2*10^5 = 6.94$

③ Friction losses

$\Delta f_R = Zero$

$\Sigma = 6.7\%$

Post tension

①

$\Delta f_{AS} = \frac{\Delta s}{2L} E_{ps}$

$= \frac{2}{8000} * 2*10^5 = 5 N/mm^2$

$\% \text{ of losses} = \frac{\Delta f_{AS}}{f_{pj}} = \frac{5}{1296.3} = 3.85\%$

②

$\Delta f_{ES} = Zero \%$ One tendom

③

$\Delta f_R = f_p [KL + \mu\alpha]$

$f_p = f_{pJ} - \Delta f_{AS}$

$= 1246.3 N/mm^2$

$\therefore \Delta f_R = 1246.3 [0.003 * 8 + 0.3 * 2 * \frac{100}{8000}]$

$\% \text{ of losses} = \frac{39.25}{1296.3} * 100$

$= 3.02$

$\Sigma = 6.87$

→ for long term losses

Pre

① creep

$\Delta f_{pi} = \varepsilon_{cr} * E_{ps} = 96$

$= 0.48 * 10^{-3} = 96$

$\% \text{ of loss} = \dfrac{96}{1296.3} = 7.4\%$

② Shrinkage

$\Delta f_{sh} = \varepsilon_{sh} * E_{ps}$

$= 0.3 * 10^{-3} * 2 * 10^{5} = 60 \, N/mm^2$

Post

①

$\Delta f_{pi} = 0.36 * 10^{-3} * 2 * 10^{5} = 72$

$\% \text{ loss} = \dfrac{72}{1296.3} * 100 = 5.55\%$

②

$\Delta f_{sh} = 0.2 * 10^{-3} * 2 * 10^{5}$

$= 40$

$\% \text{ loss} = \dfrac{40}{1246} = 3.08$

* loading Stage

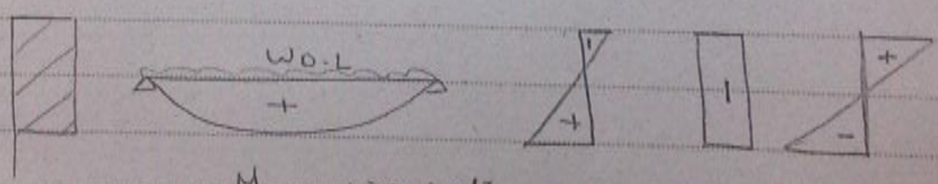
inThe Stage of Construction , the initial prestressing force and The dead load construction are effect on The normal Stress This Stage is as initial Stage alltransfer.

The charactristic Strength in Concrete.

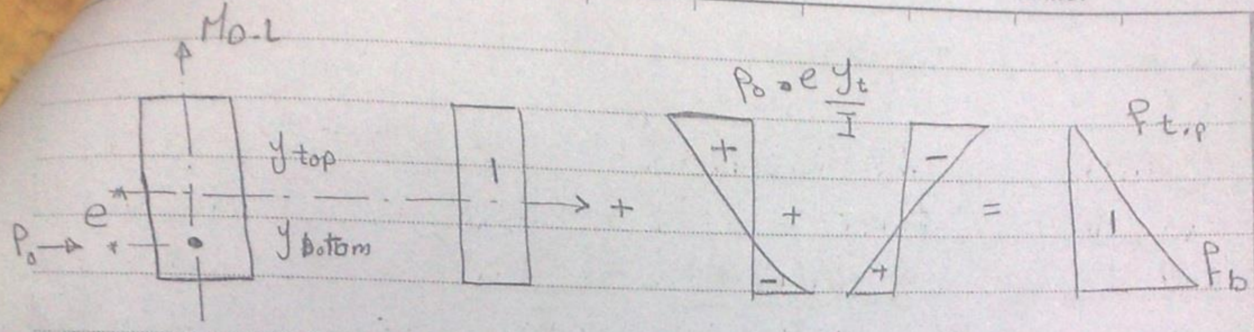
$f_{cui} = 0.75\ f_{cu}$

inThe Stage of surface building, The prestressing force [initial pre-stressed is refused to [PE] final prestressed force and the life load of building, this Stage is known as final Stage or Service Stage on

① Transfer Stage (initial Stage due to dead load + P_{A}) / working load (elastic Zone without cracks)



$M_{D.L} = \frac{W_{D.L} \times L^2}{8}$



$$F_t = -\frac{P_o}{A} + \frac{P_o \cdot e \cdot y_t}{I} - \frac{M_{O.L} \, y_t}{I} \leq 0 \qquad \ngtr 0.22\sqrt{F_{cui}}$$

Critical هي
at initial stage

$$F_b = -\frac{P_o}{A} \underbrace{-}_{\text{Compression}} \frac{P_o \cdot e \cdot y_b}{I} + \frac{M_{O.L} \cdot y_b}{I} < \underrightarrow{0.45 \, F_{cui}}_{\text{طبقا للكود}}$$

P_o ← قوه اكبر تأثيرها في Transfer stage

F_t → هتبقى حالة Critical و لذلك لابد من ان تكون
اقل من صفر حتى لا يتولد شروخ في الخرسانة او ليسمح بشد
لا يزيد عن $0.22\sqrt{F_{cui}}$
له tensile stress

② at working stage (final stage due to (D.L + L.L + Pe)

Pe → final prestress force

$$P_e < P_o$$

D.L + L.L

$$f_t = -\frac{P_e}{A} + \frac{P_e \cdot e \cdot y_t}{I} - \frac{M_{(D.L + L.L)} \cdot y_t}{I} \not> 0.4\, f_{cu}$$

$$f_b = -\frac{P_e}{A} - \frac{P_e \cdot e \cdot y_b}{I} + \frac{M_{(D+L)} \cdot y_b}{I} \leq 0 \qquad \not> 0.44\sqrt{f_{cu}} \qquad \not> 0.85\sqrt{f_{cu}}$$

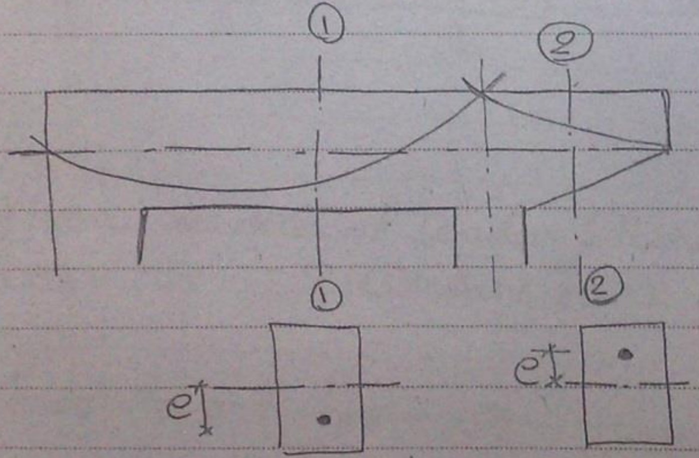
Critical at final stage

$0.44\sqrt{f_{cu}}$ → full prestressed — without crack

$0.85\sqrt{f_{cu}}$ → Partially " — with crack

وبالتالي لابد من وجود حديد للتغلب على $0.85\sqrt{f_{cu}}$

وال deflection سوف يتأثر



حالة وجود C.g فرق

كل القوانين السابقة للقطاع ①–①

Date:

في حالة القطاع (2-2)

① at Transfer stage

$$f_t = \frac{-P_i}{A} - \frac{P_i \, e \, y_t}{I} + \frac{M_{O.L} \cdot y_t}{I} \leq 0.45 \, f_{cui}$$

$$f_b = \frac{-P_i}{A} + \frac{P_i \cdot e \cdot y_b}{I} - \frac{M_{O.L} \cdot y_b}{I} \leq 0.0 \quad \not> 0.22\sqrt{f_{cui}}$$

② at working stage

$$f_{t\grave{p}} = \frac{-P_e}{A} - \frac{P_e \cdot e \cdot y_t}{I} + \frac{M_{O.L+L.L} \, y_t}{I} \leq 0$$

$\cancel{\not> 0.44}$

$\not> 0.44\sqrt{f_{cu}}$

$$f_b = \frac{-P_e}{A} + \frac{P_e \cdot e \cdot y_b}{I} - \frac{M_{(O.L+L.L)} * y_b}{I} \leq 0.4 \, f_{cu}$$

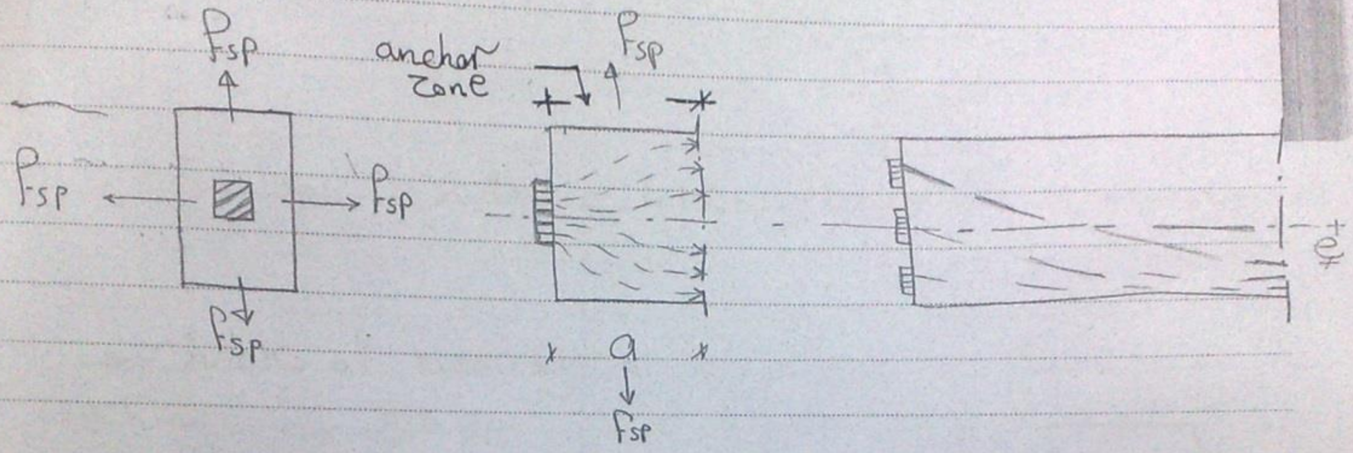
* given an area of tendom (Asp)
* Req: de Prestressing force Ceck of transfer stre

$$\left.\begin{aligned} f_{s\,all} &= 0.7 \, f_{pu} \\ &= 0.8 \, f_{py} \end{aligned}\right\} \text{ اقل}$$

$$P_{jack} = A_{sp} * f_{s\,all} \longrightarrow \underset{\text{initial}}{P_i} \xrightarrow[\text{steel}]{\text{reduct}} P_e$$

* anchorage Zone

⟹ for Post-tension method



ـه fsp تنتج لأن الاجهاد كان مختصر ثم حدث له توزيع
متوجه in Plan & elevation

نسبياً
In post tension structure relativley small anchorage Plate transfer the force from the tendon to the concrete by bearing.

anchorage Zone behind the anchorage plate may be damage due to uncontroled cracking or spliting of the concrete (due to unsuficent transverse transfer force.

Bearing failure immediatly behind the anchorage plate are also common because of the ineduate

عدم كفاية، مناسبا للاجهاد
dimension of the bearing plate for poor quality concrete

Page:

Date:

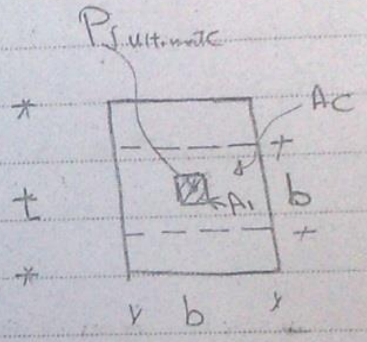
المشكلات اللى تحدث

check of bearing نقل الثلاثه crashing stress بسبب anchorage plate ①
ولو unsafe نزود مساحة plate

②

f_{spl} لابد من وجود حديد جانبي وكانات لتقاوم

→ check of bearing
crashing حرة كبيرة



$$f_b = \frac{P_{ju}}{A_1} < f_{buc}$$

where
- f_b → bearing stress
- P_{ju} → ultimate jacking load
- A_1 → area of bearing   المساحة المعرضة لمكان tendom

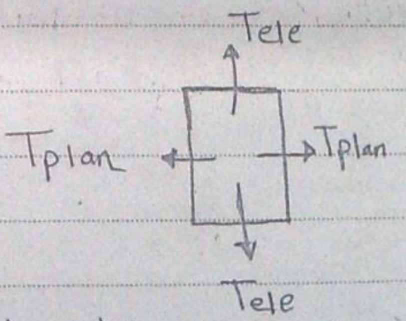
$$\Rightarrow f_{buc} = 0.67 \frac{f_{cu}}{1.5} \sqrt{\frac{A_2}{A_1}}$$

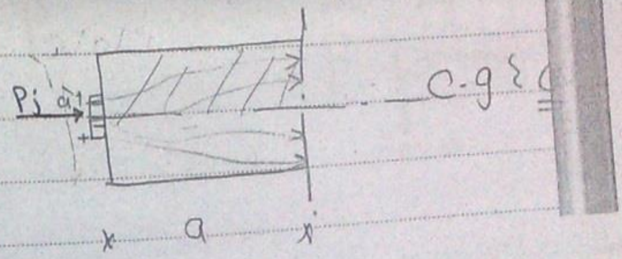
لابد with condition $\sqrt{\frac{A_2}{A_1}} \ngtr 2$

لو unsafe ← ابعاد زيادة Aplate
- او تقسيم الـ tendom الى اجزاء

Page:---------------- Date:----------------

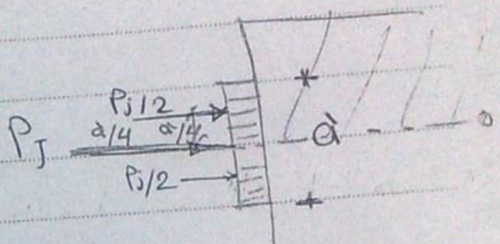
→ Design of end block (Tplan & Tele) Fspl





→ in elevation

$\sum M_o = 0.0$



$$\left(\frac{P_j}{2} \cdot \frac{a'}{4}\right) + T\left(\frac{e}{2}\right) = \frac{P_j}{2}\left(e/4\right)$$

$$T_{ele} = \frac{P_j}{4} * \left(\frac{a - a'}{a}\right)$$ plate hight ← for one tendom

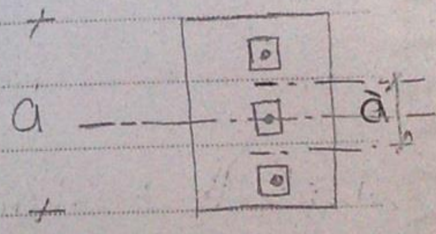
أ ارتفاع القطاع

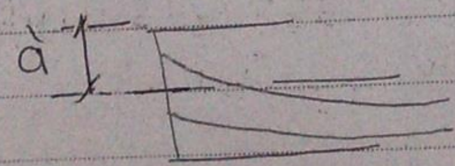
→ for more one tendom

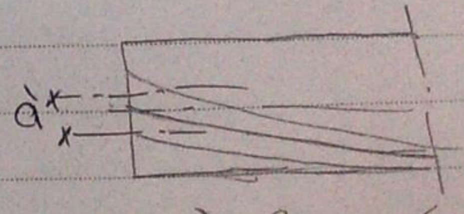
$$T_{ele} = \frac{P_j}{4 * n_{ele}} * \left(\frac{a - a'}{a}\right)$$

عدد ← elevations plate

= 3







المخصص à : 2 tendons

edge , C.L

لما كرسي 2 à هي

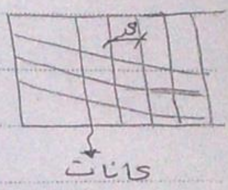
بتاعت من C.L لـ C.L

لابد من وضع كانات في منطقة anchorage لتوزيع كانات
رأسية لتقاوم Tele

المسافة بين tendom واول ف

$$T_{ele} = n * A_{st} \left(\frac{a'}{s'}\right) f_s$$

- n ← عدد فروع الكانة
- A_{st} ← مساحة مقطع الكانة
- s' ← المسافة بين فروع الكانة
- f_s ← (1400-2000)



$S \ngtr 200mm$

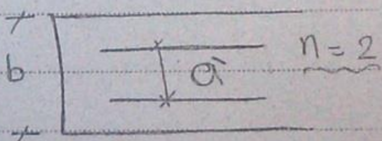
→ in Plan

Two tendom المسافة بين = (10-15 cm)

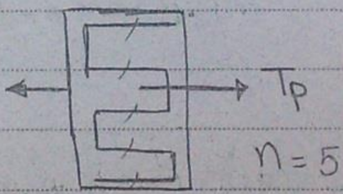
$$t_{plan} = \frac{P_j}{4 * n_{plan}} \left[\frac{a - a'}{a}\right]$$

$$T_{plan} = n * A_{st} * \frac{a'}{s'} * f_s$$

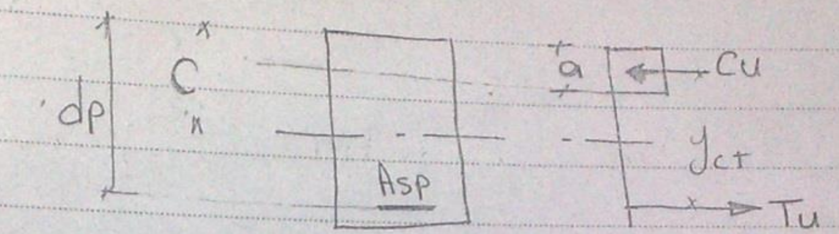
$a = b$



Plan



* check of ultimate moment



$$C_u = T_u$$

$$\frac{0.67\, f_{cu}}{\gamma_c} * a * b = \frac{A_{ps} * f_y}{\gamma_s}$$

$$M_{u.L} = T_u * (d_p - a/2)$$

$$= A_{ps} \frac{f_{yps}}{\gamma_s} * \left(d - \frac{a}{2}\right)$$

لازم $\gamma M_{u.R} > M_f$

في الحالات العادية $M_f = 1.4\, M_{D.L} + 1.6\, M_{L.L}$

في حالات الكباري
$$M_f = 1.5\, M_{D.L} + 2.5\, M_{L.L}$$
$$= 2\, M_{D.L} + 2\, M_{L.L}$$
} الاكبر

if $M_{uR} < M_f$ = unsafe

الحل ← تكبير

(a) increase depth

(b) use non-pre tension steel ← نضيف حديد بشرط

ميتحولش القطاع إلى Compression failure (اى ينهار الخرسانة أولاً)

وحتى يتحقق ذلك لا بد من شرط

$$\frac{c}{d} < \frac{c}{d_{max}}$$